The dijet cross-section with a jet veto

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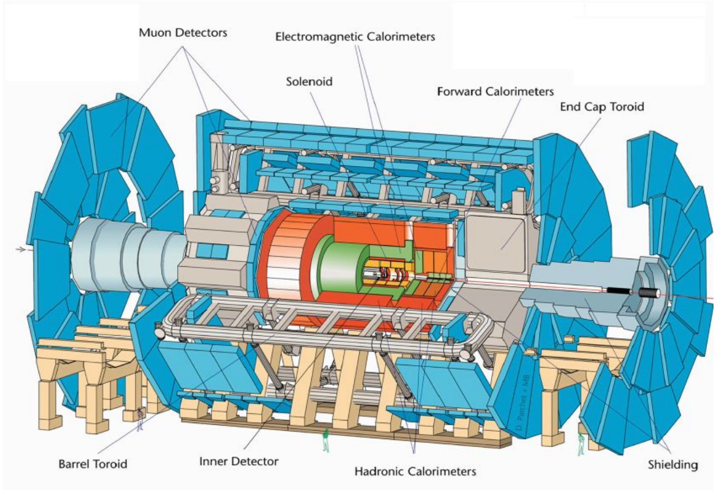
Outline

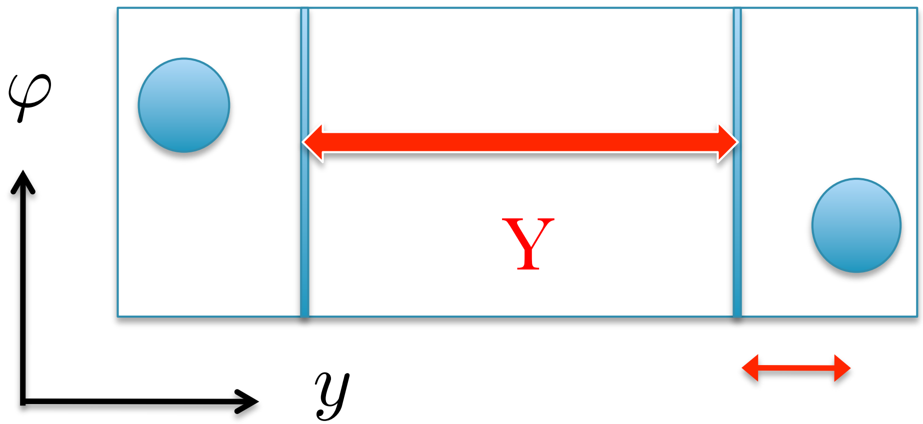
- The dijet cross-section with a jet veto
- Soft gluon resummation
- Non global effects
- Resummation VS Monte Carlo
- Resummation VS Data (work in progress)
- Conclusions

The observable

Production of two jets with

- transverse momentum Q
- rapidity separation Y



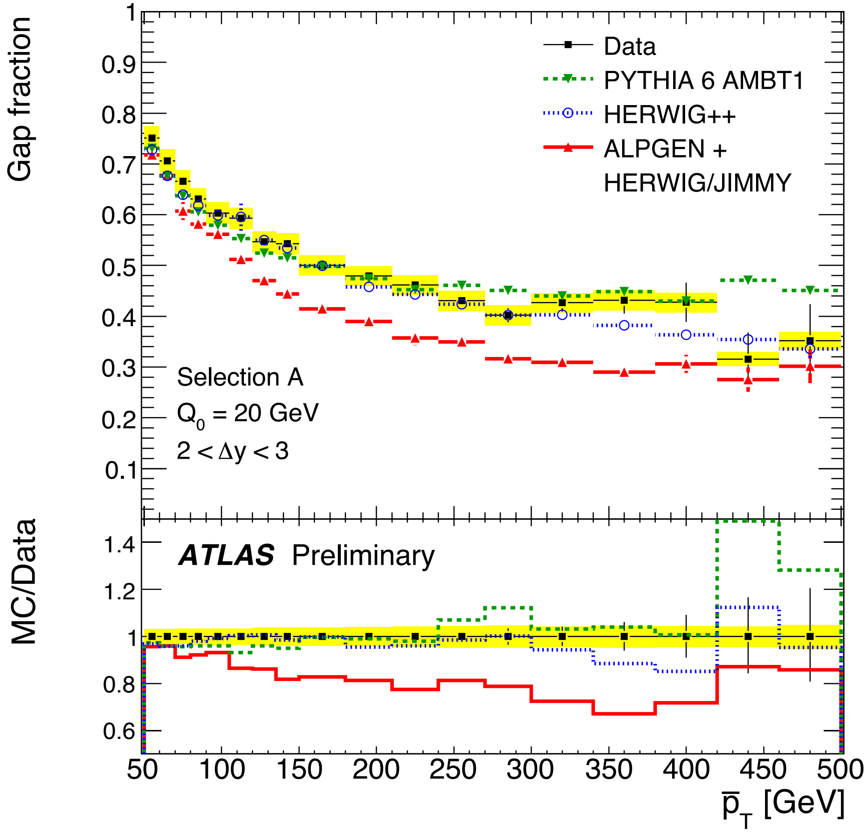


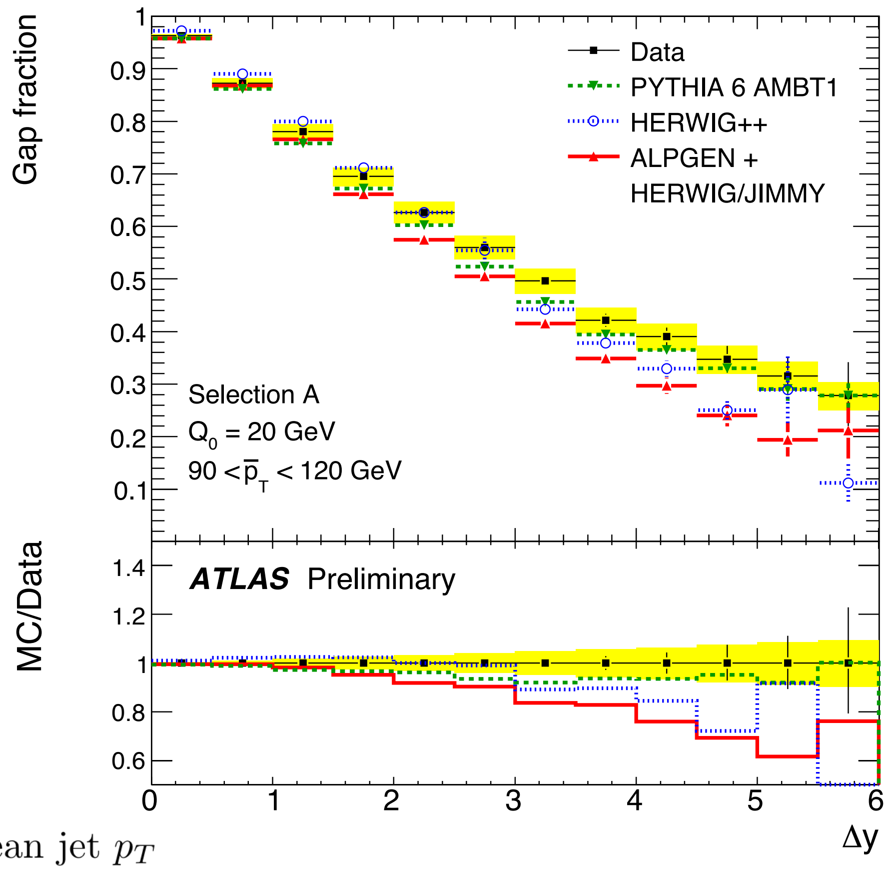
$$\begin{aligned} Y &= |y_3 - y_4| - 2D \\ D &\geq R \quad \text{azimuthally symmetric gap} \\ D &= 0 \quad \text{ATLAS choice} \end{aligned}$$

- Emission with $k_T > Q_0$ forbidden in the inter-jet region

Q_0 can be rather large: the gap is a region of limited hadronic activity

ATLAS measurement



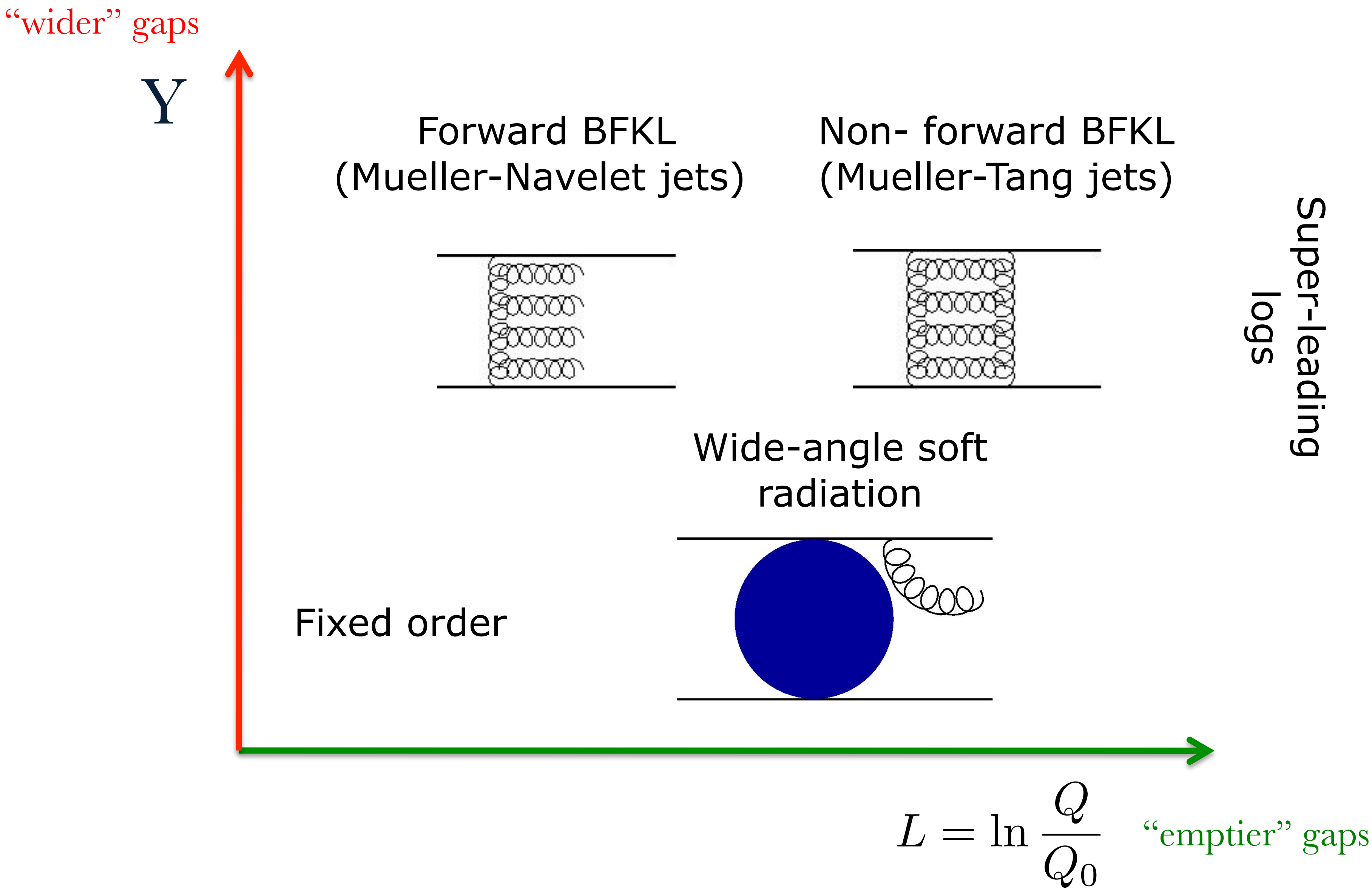


$\bar{p}_T$ = mean jet p_T

Δy = distance between jet centres, i.e. non-azimuthally symmetric gap.

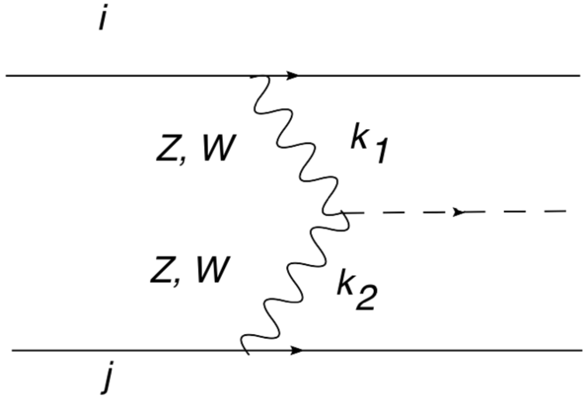
- PYTHIA seems to do a good job
- However the spread in the results of different generators is not satisfactory
- Comparison also to POWEG and HEJ (not discussed here)

Plenty of QCD effects

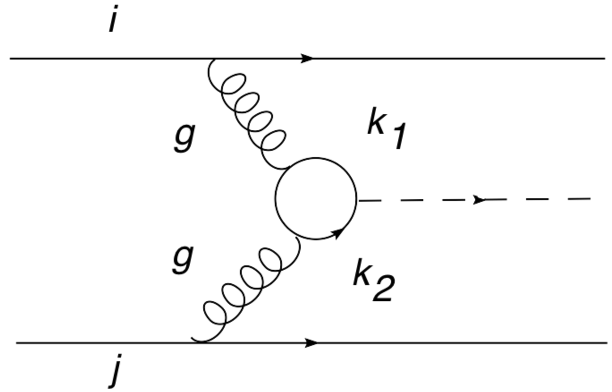


Higgs +2 jets

Weak boson fusion



Gluon fusion



- Different QCD radiation in the inter-jet region
- To enhance the WBF channel, one can make a veto Q_0 on additional radiation between the tagged jets
- QCD radiation as in dijet production

Forshaw and Sjödahl
arXiv:0705.1504 [hep-ph]

- Studying the cross-section as a function of the veto scale one can simultaneously extract the couplings of the Higgs boson

Cox, Forshaw and Pilkington
arXiv:1006.0986 [hep-ph]

Soft gluons resummation

- Real and virtual contributions cancel everywhere except within the gap region for

$$k_T > Q_0$$

  - One only needs to consider virtual corrections with

$$Q_0 < k_T < Q$$

- Leading logs (LL) are resummed by iterating the one-loop result:

$$\mathcal{M} = e^{-\alpha_s L \Gamma} \mathcal{M}_0$$

soft anomalous dimension

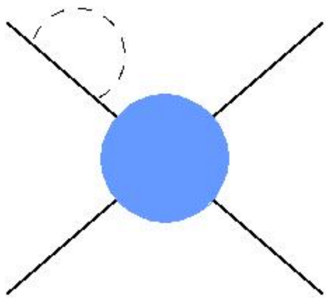
Born

Oderda and Sterman
hep-ph/9806530

Colour evolution

The anomalous dimension can be written as

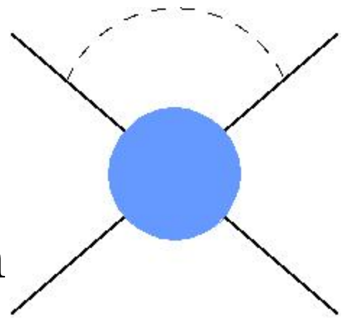
$$\Gamma = \frac{1}{2} Y T_t^2 + i\pi T_1 \cdot T_2 + \frac{1}{4}\rho(T_3^2 + T_4^2)$$



$$T_t^2 = (T_1^2 + T_3^2 + 2T_1 \cdot T_3)$$

is the colour exchange in the *t*-channel

- The *i*π term is due to Coulomb (Glauber) gluon exchange

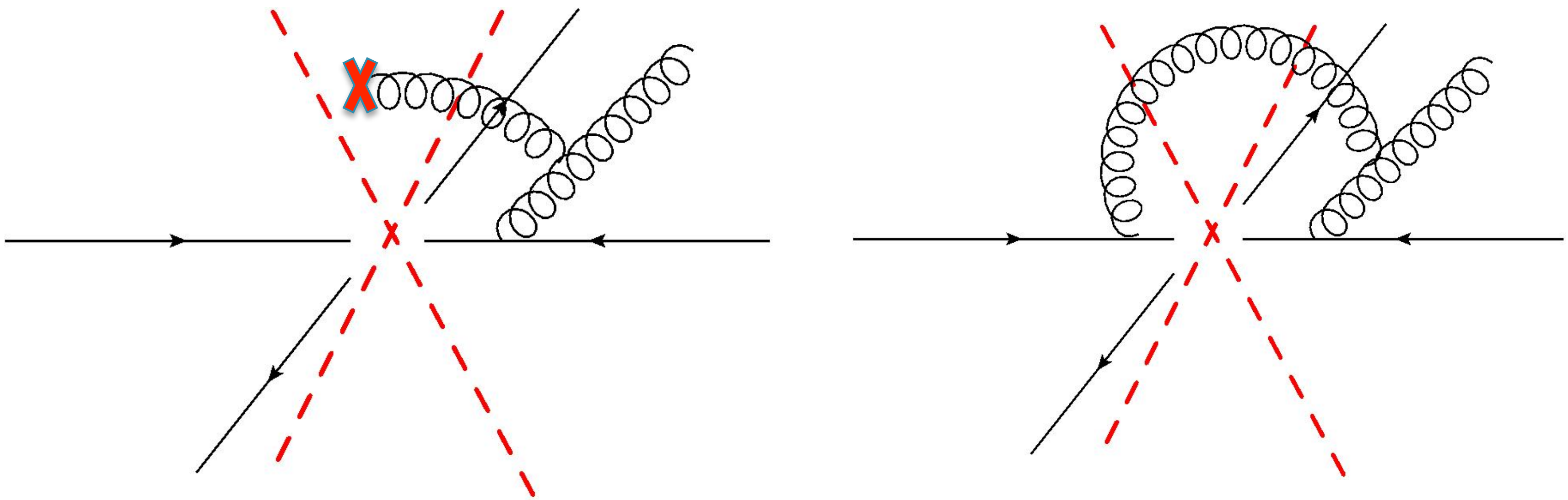


- Coulomb gluon contributions are *not* implemented in parton showers

Non-global effects

Dasgupta and Salam
hep-ph/0104277

- However this approach completely ignores a whole tower of LL
- Virtual contributions are not the whole story because real emissions out of the gap are forbidden to remit back into the gap



Resummation of non-global logarithms

- The full LL result is obtained by dressing the 2 to *n* (i.e. *n-2* out of gap gluons) scattering with virtual gluons (and not just 2 to 2)
- The colour structure soon becomes intractable
- Resummation can be done (so far) only in the large N_c limit

Dasgupta and Salam
hep-ph/0104277

Banfi, Marchesini and Smye
hep-ph/0206076

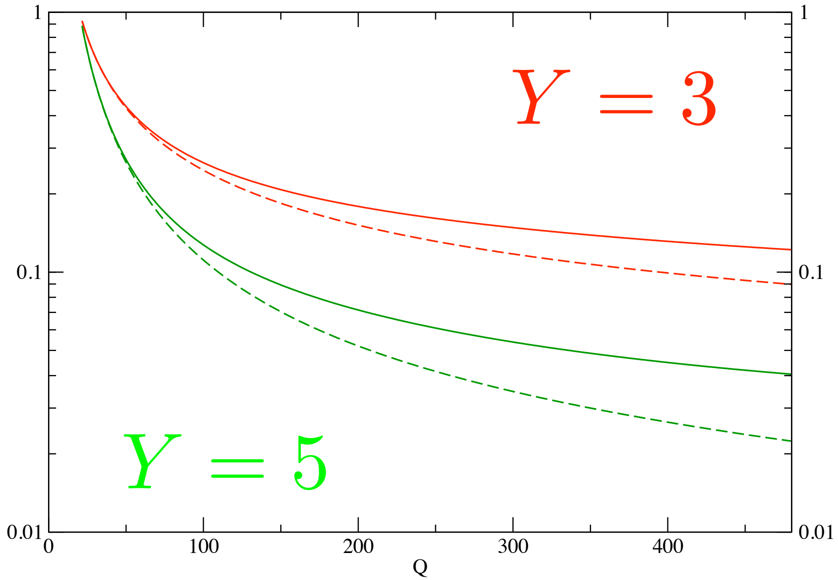
- As a first step we compute the tower of logs coming from only one out-of-gap gluon but keeping finite N_c:

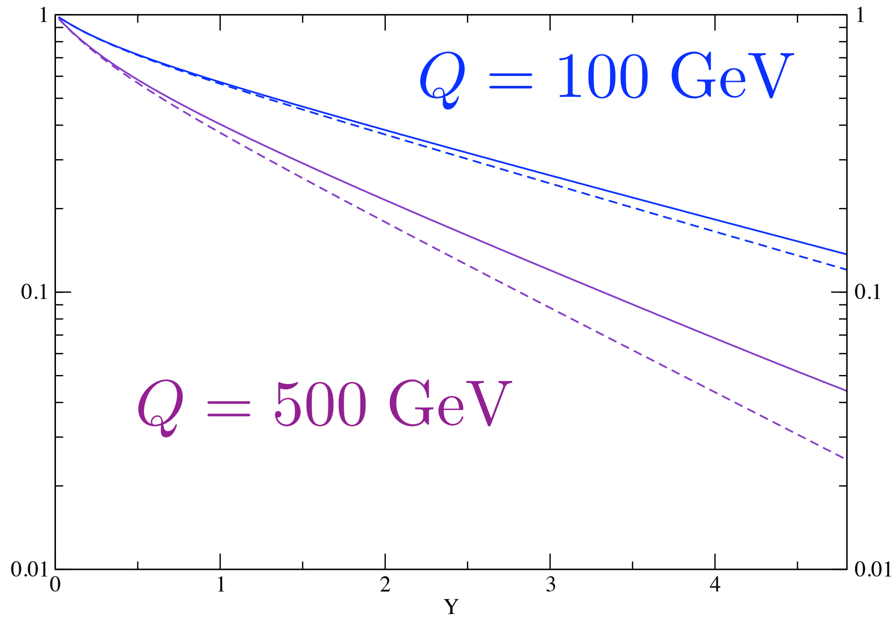
$$\sigma^{(1)} = -\frac{2\alpha_s}{\pi}\int_{Q_0}^{Q}\frac{dk_T}{k_T}\int_{\text{out}}(\Omega_R + \Omega_V)$$

Global logs and Coulomb gluons (no gluon outside the gap)

$$f^{(0)} = \sigma^{(0)}/\sigma^{\text{born}}$$

$\sqrt{S}$ = 14 TeV
Q_0 = 20 GeV
R = 0.4
η_{cut} = 4.5

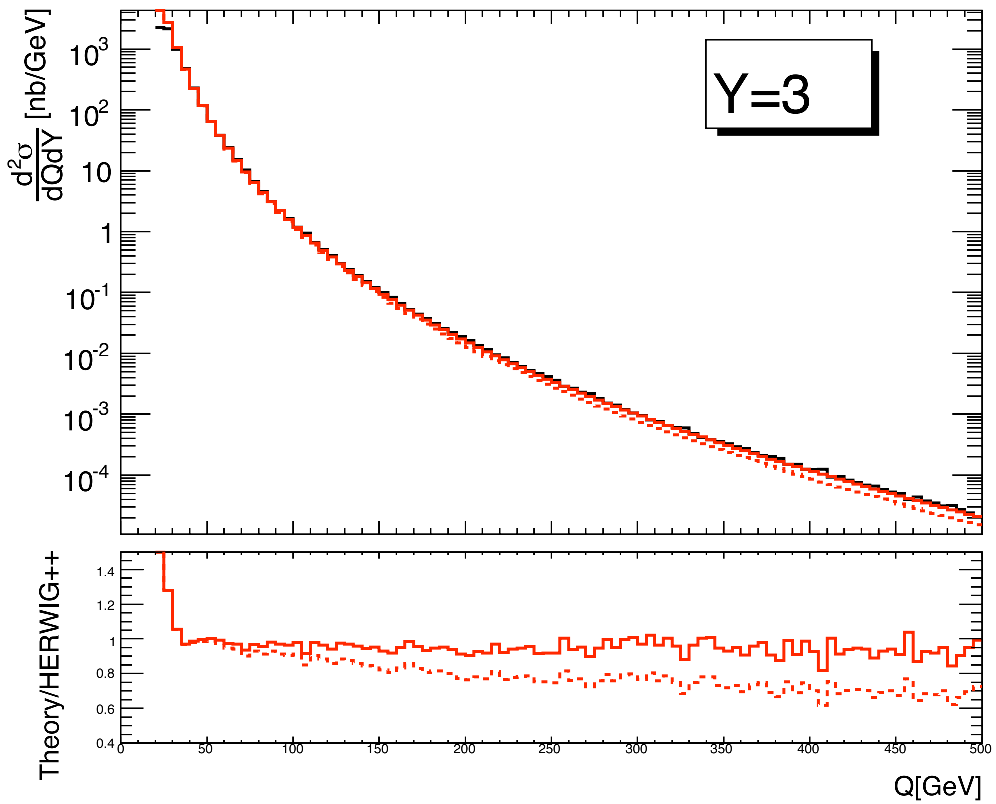




- solid lines: full resummation
- dashed lines: ignoring $i\,\pi$'s

Large Coulomb gluon contributions !

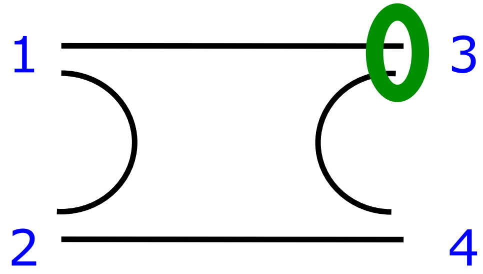
Comparison to HERWIG++ (gap cross-section)



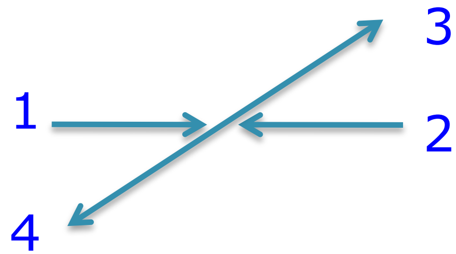
- We compare our results to HERWIG++
- LO scattering + parton shower (no hadronisation)
- Q is the mean p_T of the leading jets
- Jet algorithm SIScone

- The overall agreement is encouraging
- One should compare the histogram to the dotted curve
- Precise understanding of parton showers is important

Colour radiation in Herwig++



- The colour partner of gluon 3 is chosen in each event between 1 and 4 with equal probability
- If the partner is on the same side of the gap there is very little radiation



- Inclusive interjet radiation

dipole

$$\text{jets} \quad 4 \times \frac{1}{2} \times \frac{1}{2} \times N_c = N_c$$

partner across the gap

- Suppression factor for radiation in the gap

$$e^{-N_c \rho \xi} \left[\frac{1}{2} + \frac{1}{2} e^{-N_c Y \xi} \right]^4 \simeq \frac{1}{16} e^{-N_c \rho \xi}$$

- This vanishes slower than the soft gluon exponential

$$\sim \sum_i e^{-N_c (\rho + A_i Y) \xi}, \quad A_i > 0$$

- This led to a modification of the Herwig++ parton shower

Schofield and Seymour
arXiv:1103.4811

Resummation and kinematics

- When compared to the data our resummation performs poorly
- Why is that?

  - has the full colour structure

  - has approximate non-global logs

  - does not conserve energy and momentum (eikonal approximation)

- Because of the fairly large value of Q_0 the region considered is not asymptotic and fixed-order effects are not negligible

- Thus we need matching to fixed order

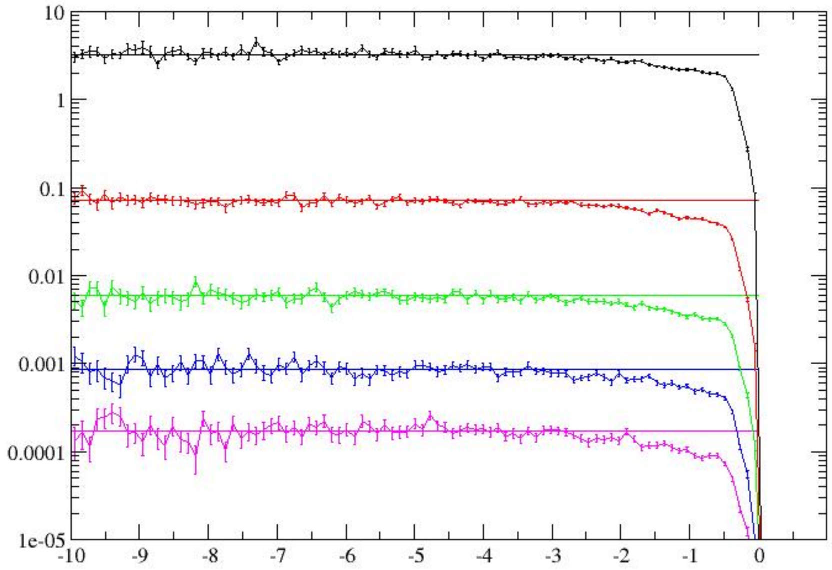
Matching to fixed order

$$f = 1 + \alpha_s c_1 + \alpha_s^2 c_2 + \ldots$$

- Fixed order computed with NLOJET++
- Check of the logs using the distribution

$$Y = 3$$
$$Q = 100 - 500\,\mathrm{GeV}$$

$$\frac{d\sigma}{d\ln Q_0 \, dQ \, dY}$$

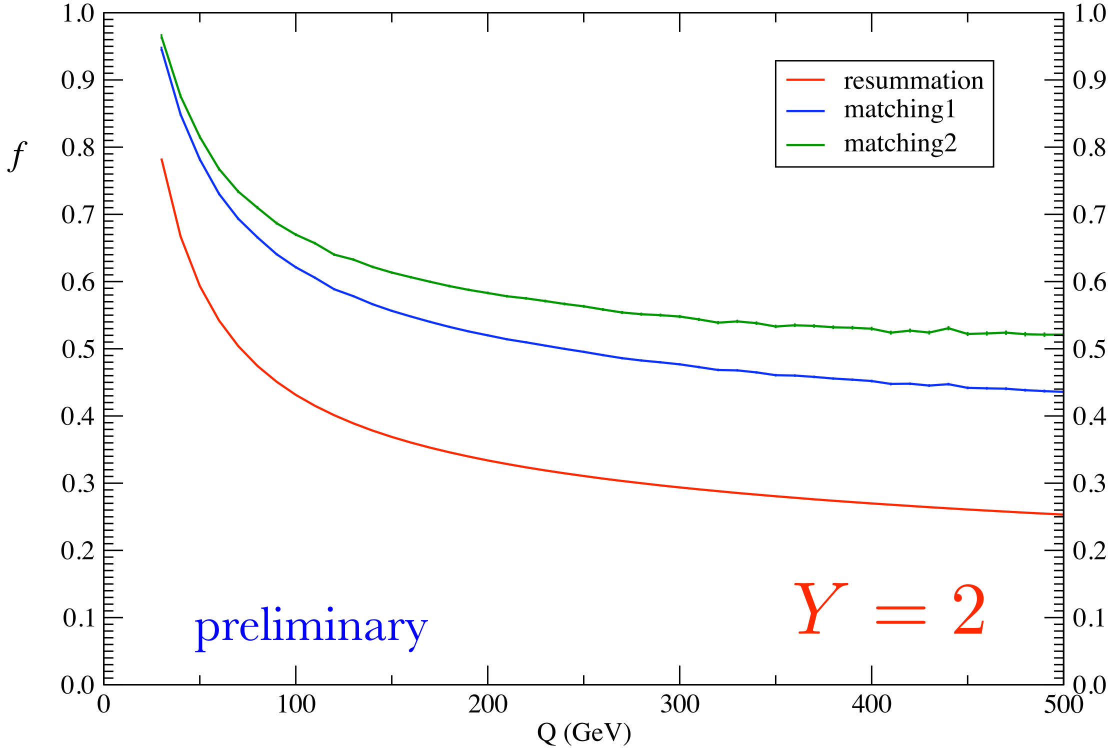


$$\ln \frac{Q_0}{Q}$$

- The LO matching can be done with just tree-level matrix elements: studies with Madgraph as well

The matched gap fraction

$$f = f_{\mathrm{res}}(1 + \alpha_s c_0)e^{\alpha_s d_0}$$



$$b_0 = c_0 + d_0$$

Obtained from fixed order calculation with the logarithm subtracted

To do:

- check these results
- include non-global logs
- include scale uncertainties
- matching to the next order

Conclusions

- I have discussed the dijet cross-section with a jet veto
- This observable has been already measured by ATLAS
- It is sensitive to soft-gluon radiation and non global logarithms
- An analytical study suggested a way to improve parton showers
- In order to perform phenomenology our resummation must be matched to the fixed order calculation (work in progress)